Geophysical Research Abstracts
Vol. 16, EGU2014-6543, 2014
EGU General Assembly 2014

Organic matter mineralization in frozen boreal soils-environmental constraints on catabolic and anabolic microbial activity

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Heterotrophic microbial mineralization of soil organic matter (SOM) and associated production and emission of atmospheric trace gases proceed during the winter months in the frozen soils of high latitude ecosystems. However, in what ways this microbial activity is constrained by the environmental conditions prevailing in a frozen soil matrix is uncertain. This presentation will address how temperature, water availability and substrate availability combine to regulate rates of microbial activity at below freezing temperatures and the implications of this activity for SOM mineralization in the surface layers of boreal forest soils experiencing seasonal freezing.

We show that the amount and availability of liquid water is an integral factor regulating rates of microbial activity in the frozen soil matrix and can also explain frequently observed deviations in the temperature responses of biogenic CO_2 production in frozen soils, as compared to unfrozen soils. Using stable isotope labeling (13C) we also show that the partitioning of substrate carbon, in the form of monomeric sugar (glucose), for catabolic and anabolic metabolism remain constant in the temperature range of -4C to 9C. This confirms that microbial growth may proceed even when soils are frozen. In addition we present corresponding data for organisms metabolizing polymeric substrates (cellulose) requiring exoenzymatic activity prior to substrate uptake.

We conclude that the metabolic response of soil microorganism to controlling factors may change substantially across the freezing point of soil water, and also the patterns of interaction among controlling factors are affected. Thus, it is evident that metabolic response functions derived from investigations of unfrozen soils cannot be superimposed on frozen soils. Nonetheless, the soil microbial population appear very adapted to seasonal freezing with respect to their metabolic performance.